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The Elms and Their Diseases.

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
LEXINGTON, KY.

Bulletin No. 84.

The Elms and Their Diseases.

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

Frequent complaints have appeared in our newspapers concerning the dying of elm trees in central and eastern Kentucky. In a variety of situations, along the streets of cities, about lawns, in woodland pastures, and at the edges of streams, elm trees have stood during the past summer with naked branches, when all was green around. Small and large trees are affected. It is a current notion that some little-understood epidemic, infectious disease is taking the trees, one recent writer specifying so far as to style it zymotic in character, while others have prescribed treatment suggesting that the trouble has something in common with the intermittent fever of man.

Three distinct species of elms are frequent in cultivation in Kentucky, and two others are common along some of our streams, and the mystery surrounding the death of one tree while another near by has all the appearance of health is sometimes due to a failure to recognize the difference between our white elm (*Ulmus americana*), the tree that is really dying in some parts of the State, and its relative, the red elm (*Ulmus fulva*), which holds its own in any situation. Both are beautiful trees with some general resemblances, and when young are likely to be confounded by the unscientific. The third species most commonly seen in cultivation is the English elm (*Ulmus campestris*). In some of our smaller cities this

elm predominates as a shade tree along the streets, native elms being rather scarce. In Nelson county it has been badly defoliated for several years past by the imported elm leaf-beetle (*Galerucella luteola*), and the trouble has in some instances been confounded with the white elm disease. The elm leaf-beetle does not often attack our native elms severely even when they grow near badly infested English elms, and so far as I have observed, the white elm disease does not affect either the red or the English elm.

Several additional exotic elms are in cultivation in America, among which is the Scotch or wych elm (*Ulmus montana*), very likely to be encountered in Kentucky parks, but the following are of special interest to Kentuckians from their abundance, in cultivation and out.

1. The American or white elm (*Ulmus americana*). Leaves smooth and somewhat glossy above, of medium size, with about twelve veins extending outward from the midrib on each side, not very deeply impressed, while the veinlets show scarcely at all. Twigs and buds smooth, the latter rather small and elongate in winter. No corky growth on the branches. Seed with surfaces smooth, the margin of wing fringed. Bark rather smooth in young trees, becoming rougher with age, finally grooved lengthwise of the trunk, its color dark gray. Wood moderately tough, hard, and close-grained, taking a very good polish, but checking quickly when not seasoned properly. The largest of the elms, often reaching a height of one hundred feet.

This elm is best known in America as a shade tree along the streets of cities. Its massive trunk produces a short distance above the ground numerous rather slender branches which extend outward and upward then turn outward with a long sweep and final droop, the gracefulness of which is its chief attraction. The bark is not so irregularly roughened as that of the red and cliff elms, and one can quickly distinguish this species from the others by this character alone. The wood lasts well under water, and has been used for ship building. Young trees about 25 feet high, recently examined by me, had grown at the rate of six inches in diameter of trunk in

fifteen years*. The white elm thrives in deep rich soil. It is seen at its best in valleys and along streams. On uplands it is not so common, nor so stalwart in size.

In this State it has been noted from time to time in Gallatin, Shelby, Franklin, Fayette, Jessamine, Mercer, Rockcastle, Breckinridge, Grayson, Edmonson. Warren, and Hickman counties.

2. The red or slippery elm (*Ulmus fulva*). Leaves large, oval, rough to the touch, downy beneath, with about sixteen veins on each side of the midrib, deeply impressed, as are also the veinlets, giving the surface a rough appearance. Buds large and oval in fall and winter, with a brown pubescence. Wing of seed obovate in outline, not fringed ; surface of seed only, pubescent. Bark dark in color, rough, especially in young trees where it resembles that of the hackberry. Inner bark containing a mucilaginous substance employed in medicine and giving origin to the name slippery elm.

While this tree lacks the stateliness of the white elm, it has a beauty of its own that entitles it to a place on the lawn and in the park. It does not often exceed sixty feet in height, and is disposed to send its branches out horizontally, giving the crown a very different character from that of the white elm. Many red elms are seen in cultivation in Kentucky, having, I suspect, been planted in some instances by mistake. The roughness of its leaf is a ready means of distinguishing it. Its characteristic roughness of bark, also, will enable any one familiar with elms to pick it out at a glance. The leaves are often of very large size on young trees, some of those from a tree growing near the Station building measuring eight inches in length and four inches in diameter. It is partial to rich, damp soil, and is in consequence most common in the vicinity of streams, but trees are to be encountered widely scattered in our forests.

*Laslett, the British authority on timbers, is surely mistaken when he says (Timber and Timber Trees, p. 179) that its wood diameter increases only about one inch in fourteen years Though he employs the name *Ulmus americana*, it seems very likely that his statement was based upon an examination of the cliff elm (*U. racemosa*), which is very slow of growth.

It has been noted by me in the following counties: Boyd, Greenup, Wolfe, Fayette, Anderson, Woodford, Jessamine, Rockcastle, Whitley, Hardin, Grayson, Edmonson, Warren, Hickman.

3. The cliff or rock elm (*Ulmus racemosa*). Leaves smooth and glossy, of medium size, with about twenty straight and nearly parallel veins on each side of the midrib; but little impressed, and only occasionally forked before reaching the margin. Winter buds not large and round-oval. Wing of seed oval in outline; not widest outwardly; everywhere downy; long-stalked. Bark light gray and rough, like some of the oaks. Branches with corky knots and irregular ridges; these not present, however, on the new growth. Wood very hard, taking a fine polish.

I have seen this tree in cultivation, but it is not handled so far as I know by local nurserymen, and is not well known in the State, except to wood-cutters in regions where the species grows. It is common along cliffs and rocky banks of the Kentucky River. The trees I have seen thus far are not large, the trunk not exceeding ten inches in diameter, and the height not above forty feet. At the North the species grows to a height of 100 feet or more. The cliff elm is well known to people residing on the banks of Kentucky River, who seem to be impressed more by the hardness of its wood than by any other character. At Brooklyn Bridge, Jessamine County, numerous young elms of this species grow up along the faces of the cliffs, the roots penetrating soil that has accumulated on ledges and in crevices. The wood is harder than that of any other elm native to the State, and is valued for uses requiring strong and durable timber, such as bridge building. Quantities of the timber have been shipped to England from the United States and Canada. A section of a small tree now before me shows eighteen annual rings with a diameter of but two and a half inches. At the same age a white elm would have had more than twice this diameter.

The handsome, glossy leaves with numerous parallel veins, together with the irregular corky growths on the branches, are the most convenient characters for distinguishing this elm.

The only other native elm with these corky growths is the next, and it is a small tree with small leaves, the corky growths of twigs generally in the form of two ridges, one on each side.

The cliff elm has been observed by me along Kentucky River, in Fayette, Jessamine and Mercer counties. Recently Dr. A. M. Peter, of the Station, has called my attention to a clump of these trees standing on the bank of North Elkhorn Creek, about seven miles north of Lexington. A partly decayed trunk observed here measured fifty-four inches in circumference, at about three and a half feet above the ground.

4. The winged elm (*Ulmus alata*). Leaves small, lanceolate; veins on each side of the midrib about 10, not strictly parallel. Buds small. Seed elongate, the wing fringed at the margin. Branches with flat, corky ridges, generally one on each side; these present even among the leaves on the young growth.

This little elm is generally less than forty feet high, and not often more than a foot in diameter of trunk. So far as I know its wood has no great value. Its distribution outside our borders is southern in general, and it has been observed by me only in the southern and western parts of the State.

It is more or less common in the following counties: Bell, Whitley, Rockcastle, Breckinridge, Grayson, Edmonson, Warren, Logan, Todd, Ohio, Christian, Hopkins, McCracken, Fulton, Hickman.

5. The English elm (*Ulmus campestris*). Leaf smooth on large trees, of medium size, broad oval in shape and disposed to be one-sided. Seed placed near the outer end of the wing. Branches (sometimes with corky growths) directed upwards and horizontally, the lower sometimes drooping so that they can be reached from the ground. Bark rough. Wood hard.

This imported elm is very different from ours in its manner of growth. The crown is compact like that of some of our oaks and throws a dense shade. It does not grow to as great a height as either the white or cliff elm. In European countries the wood is valued above that of our species. In culti-

vation the tree varies widely, and some of these variations pass as distinct species with those who are not informed as to their history.

The Scotch or wych elm (*U. montana*) has a rough leaf like our red elm, but its buds are not downy. It is the only other imported elm likely to be encountered in the State ; but it presents some puzzling variations that may lead to the impression that we have many European elms.

THE WHITE ELM DISEASE.

Beginning in 1892 and continuing with greater or less frequency ever since complaints have reached me concerning a diseased condition of elm trees in this State. As early as December, 1893, a bulletin prepared by me was issued by the Station in which (p. 44) is a discussion of the trouble, with suggestions as to remedies. Previous to 1892 there is every probability that the trouble was under way. It was observed in Massachusetts in 1847, and in Illinois in 1883.

Since the "passing" of our elms has thus continued far so long a time without reaching an end, we may hope that some of these beautiful trees will still remain at the close of another half century. But if the death rate continues as during the past two years this hope is not to be realized in Central Kentucky.

The first discernible evidence of disease is a loss of the leaves at the ends of twigs, often at the tops of the trees. As the trouble extends towards the trunk the foliage gradually drops from other parts until finally the tree stands bare. The fallen leaves may show no mark of insect work, certainly none that could cause them to let go their hold on the branches, and the only thing abnormal about them is a discoloration, sometimes present, like that due to the blight fungus of potatoes, the tips or side regions being more or less extensively black. Most of the affected twigs show no external evidence of injury, but in still living trees one may sometimes find part of them thickly covered with little red wart-like pustules, 1-25 inch and less in diameter. These represent a fungus that passes its early stages in the bark and emerges in this shape to develop its

fruit. It is perhaps not actively parasitic, but appears occasionally to invade the wood of trees enfeebled by other causes.

The twigs are sometimes scored also by the buffalo tree hopper (*Ceresa bubalus*) which deposits its eggs in the bark, and old marks of this work are likely to be found on elm trees in this region.

By cutting into the bark of the twigs one may find about the bases of lateral shoots the burrows of a beetle, the small, white, "flat-headed" grub of which eats out the inner layer of bark. It resembles very closely in shape the flat-headed apple tree borer, well known to fruit growers, and belongs to the same family of insects. I find it present in trees not yet dead, but thus far always in dead wood, so that it seems unsafe to pronounce it the cause of the dying, and in fact a tree was recently examined in which none of these twig-infesting grubs could be found. At farthest it is to be considered, like the fungus previously mentioned, a help in the destruction of the tree.

In the inner layer of bark of the trunk, anywhere from the ground up to the bases of the first branches, one will find in most, perhaps all, dying elms the grubs of a wood-boring beetle. The fact, so far as my own experience goes, is that while I have not in one or two cases found these grubs in the bark of trees examined while standing and still living, I have never made a *thorough* examination of a diseased tree, living or dead, without finding some of them.

In August, 1899, two white elm trees growing on the College grounds were dug up and examined from the roots to the tips of the branches. One was alive but showed the disease in naked twigs at the top; the other was dead. They were both about 25 feet high, had a trunk diameter of about seven inches, and appeared to be of the same age, about 18 years. The living tree, when the bark of the trunk was removed from one side, was found to have been attacked by the grubs of a small beetle,* which occurred in large numbers

*Probably *Magdalis armicollis*, a curculio known to infest elms. A part of the trunk is now sealed up in boxes to get the adult when it emerges. Until then it will be impossible to identify them positively.

in burrows made in the inner bark. With them were a few larger grubs of the well-known elm-tree borer (*Saperda tridentata*), a member of a family of wood-boring beetles. A few adults of a third bettle* were found starting burrows in the bark preparatory to placing their eggs. Only one side of the tree was occupied by the grubs, but on this side they were present from the surface of the ground up to the origin of the branches. In some of the twigs were found some of the flat-headed grubs† already mentioned, but they were not common and had evidently but recently become established there. Most of the twigs were sound, and many bore some leaves. On some of the dead ones was present some of the red nodules of the fungus mentioned in another connection. The roots were followed out from the tree to a distance of nineteen feet, and proved to be sound except that the bark when cut into was discolored, and no doubt had ceased to perform its functions some time earlier. The bark of many of the dying twigs was also found to be of a rusty color, though no other evidence of disease was apparent.

The dead tree was in much the same condition as the other, except that the elm borers were here very numerous and had occupied most of the inner bark. The roots were not injured by insects, nor were the twigs mined to such an extent as to give ground for assuming that the injury had started in them. Everything, in short, pointed to the borers in the bark as the immediate cause of the dying.

But insects are not the first cause of the dying.

The white elm has a peculiar way of sending its main roots out close to the surface of the ground. Sometimes a root upon which a tree chiefly depends is covered in places with less than two inches of soil. Roots after leaving the base of the trunk actually turn toward the surface, where they extend for long distances in the rich surface soil. The trees taken up on the college grounds for examination illustrate the point very well. The living tree had three main laterally directed roots of this

*One of the Scolytidæ, *Hylesinus opaculus.*

†I have reared the adult flat-headed apple tree borer (*Chrysobothris femorata*) from diseased elm, but these small grubs are probably the young of some other beetle of the same family.

sort. They were vertically flattened for about eight inches and then contracted rather abruptly to two inches in diameter, tapering gradually from this point to their extremities. After leaving the trunk they rose toward the surface and lay for a distance of nineteen feet out from the tree among the roots of clover and grasses. Besides their main roots were a few whip-like roots of the same sort, lying even nearer the surface than the large ones. The only other roots present were eight small brace roots from one-half to one inch in diameter, which extended downward into the soil at an angle of about 45 degrees. So long as they were uncut the tree stood firmly in place, though the soil was removed for a depth of several feet. The long lateral roots were all cut and still the tree could not be moved until these little roots were severed. The second tree had more of the lateral roots, but they arose and extended outward like those of the first. The brace roots were of the same character and of about the same number.

Trees with such a root system are adapted to alluvial soils, rich and easily penetrated. A certain amount of moisture is also essential to them. Under natural conditions elms grow among other plants, interspersed with other trees. The ground, besides being rich and from situation moist, is protected during winter by a mulch of dead leaves and in summer by shade and perhaps a tangle of undergrowth. Soil so protected does not give up its moisture quickly. But let such trees be exposed to the heat of the summer sun by cutting away all other trees, or by keeping the grass browsed or mowed closely over their long roots, and they become enfeebled in time ready to succumb when any sudden and exceptionally severe drought or freeze comes. Even if the removal of our forests had no other effect than exposing the soil to the sun it is probable that such isolated trees would suffer in time. But removal of vast tracts of forest, coupled with tillage and other processes involved in peopling a country, is known to encourage drought in other ways: By favoring a rapid escape of rainfall by surface drainage, a process that is accelerated artificially by ditching, tile draining and the like, eventually leading to constant late summer droughts from which not only trees but

all other plants suffer. A tree with an extensive root system may not show the effect in one year, or two, but in the course of many years the available food supply becomes exhausted, having been in part leached away by the running waters, and no fresh humus being supplied, the inevitable result is exhaustion for lack of both food and moisture. The effect shows first by the death of tips of branches, the tree not having vitality sufficient to keep up the circulation in the extremities, and the tree becomes "stag headed," to use an imported term.

If one looks about in Bluegrass Kentucky he will see many trees in this condition, oaks, ash and maples. The trouble is of course more or less serious according to the exposure of the roots.

Not only do trees fail to show signs of suffering immediately after the surface is cleared, but it is known to experienced foresters that for a time they grow more rapidly and appear to be in better condition. This is explained as the result of an increased food supply, due to the removal of competitors, to a more rapid decomposition of humus, which results from exposure to the air, and to increased sunlight. It is only after a considerable period that the final effect of deforesting is felt by the trees and perceived by man. Such results are not restricted to this country, but are known among foresters the world over.

I take it we are now witnessing some of these effects in Kentucky, and that our elms feel the change most keenly because of their manner of rooting. The debility brought about by unfavorable conditions such as those described is taken advantage of by the elm tree borer* in some cases, which completes the ruin by girdling trees under the rough outer bark.

This explanation carries its own suggestions as to means of saving the affected trees. Possibly a mulch of humus consisting of decayed leaves and other nutrient materials could be spread on the ground under the trees to supply the food needed and to protect the soil from rapid evaporation, and from heat

*Two other beetles belonging to the same family as the elm borer, were reared by me some years ago from diseased elms, they are *Dularius brevilineus* and *Xylotrechus colonus*.

FIG. 1.—A, showing buds and leaves of red elm (*Ulmus fulva*); B, showing buds and leaves of white elm (*U. americana*); C, twig of white elm showing grooves made by the buffalo tree hopper in depositing eggs; D, red fungus (*Nectria sp.*) sometimes present on dead twigs of diseased white elms. A and B, reduced in size. C and D, natural size.

FIG. 2.—A, twig and leaves of winged elm (*Ulmus alata*); B, leaf of English elm (*U. campestris*); C, leaf of cliff elm (*U. racemosa*); D, twig of cliff elm showing irregular corky growths E, seed of cliff elm; F, seed of red elm.

FIG. 3.—Stag-headed chinquepin oak (*Quercus acuminata*), growing on the Experiment Farm.

FIG. 4.—A diseased white elm (*U. americana*) growing on the State College grounds. Photographed August 28, 1899.

FIG. 5.—Showing the roots of a diseased white elm taken up on the State College grounds. Seen from beneath.

FIG. 6.—The same elm after the roots were uncovered and before it was taken out of the ground. A, B, C, the three main lateral roots; D, continuation of the root C, its extremity nineteen feet from the trunk shown at E.

and cold. At the least, the natural mulch under trees should not be destroyed.

To prevent the injuries of the beetles the suggestion made by me in the bulletin on shade tree insects, and already referred to, must be repeated, namely, the coating of the bark with whitewash containing Paris green or arsenate of lead to prevent the placing of the eggs. The smell of carbolic acid is repulsive to insects, and a little of this might be added to advantage. The borers find rough places on the bark to place their eggs, and cutting away the corky outer layer before applying the whitewash is to be recommended, not only as rendering the surface less attractive to the egg-laying adult, but also as exposing any insects already in the bark to the sun, which is said to destroy them. Quite often the grubs get into the bark at an injured place and spread from this. Such injuries should be sought for, and when found the dead bark be cut away. In some cases the beetles themselves will be revealed and may be destroyed so as to prevent further injury. If the injured place is not extensive, by washing it with a solution of bluestone and then wrapping with stout paper for a time the bark may close over the wound. Such injuries to fruit trees are often treated in this way, and trees threatened with destruction may thus be completely restored.

It is a well known fact that wood-boring beetles spread from diseased trees to others standing near, and to this extent the elm disease may be said to be infectious. They may even be brought into a neighborhood in rough lumber. It follows that dead elm trees and those so badly injured that they cannot recover should be be burned as promptly as possible. The grubs are in the bark in winter, and this is the best time to dispose of such trees. In summer the adult beetles are abroad for a considerable period engaged in placing their eggs, and hence destroying trees at this season is not so likely to get all of the insects. The burning should not be delayed, however, on this account.

Spurious Remedies.

Whenever any disease appears, either of man, of animals, or of plants, some cure-all bobs up and is hailed by the gullible

among human kind as a great scientific discovery. The elm tree disease is not without its unfailing remedy, and more of them are probably to follow. Time and again such bogus remedies are relegated to the limbo from which they have been resurrected, only to be dragged forth again on some new occasion. The *Industrial Gazette*, of Louisville, Ky., published the following in December, 1866:

"A gentleman of Rochester [N. Y.] was lately in Saratoga County, and was there shown an apple tree in fine healthy condition, which had been ill, subjected to treatment with calomel, and thoroughly cured. This tree was afflicted with insects, which were destroying it and rendering it unproductive. A hole was bored into the body of the tree nearly through the sap, and two grains of calomel inserted. As soon as this calomel was taken up by the sap, the vermin on the tree died, and it began to bear fruit and has done so for three years, to the entire satisfaction of the owner. Sulphur may be mixed with the calomel and produce a good effect. This is a fact worth knowing."

Commenting on the above at the time, the editor of one of our entomological journals said, among other things: "I lately heard of a lady who was cured of a violent headache by her husband presenting her with a new bonnet. As soon as the bonnet was put on her head, the headache left her, and never returned for three or four years afterward." The proof of cure is just as good in one case as in the other. It is a well known fact that neither sulphur nor calomel is soluble in water and hence they are not likely to be appropriated by trees in the way supposed. It has been proved by actual test that sulphur introduced in augur holes made in fruit trees remains there intact for years, in one recorded instance until found, to the great astonishment of a wood-chopper, in the family woodpile. After all, it must be said of such remedies that they imply in their originators a very different type of mind from that of the superstitious man of olden times who looked upon the dying of certain trees as a premonition of disaster and, thus paralized, did nothing to check the trouble.

"'Tis thought the king is dead; we will not stay,
The bay trees in our county are all withered."

THE IMPORTED ELM LEAF-BEETLE.

(*Galerucella luteola.*)

A letter from one of the Sisters at Nazareth Academy, Nelson County, dated June 20, 1898, was received by me, in which the writer stated that hundreds of beautiful English elms on the Academy grounds were then being defoliated by insects, examples of which were sent me with the letter. These proved to be the above beetle. It had appeared at Nazareth three years before, having probably been brought from some eastern State. Since that time it has spread rapidly in the neighborhood, wherever English elms abound, and last June was noted by me as injuring trees along the streets of Bloomfield, at Fairfield, and at Copperas Creek. September 18th of this year I spent a few hours at Bardstown, and found the trees, of which there are numerous fine ones along the streets, badly defoliated, in some cases with only the gnawed remnants of leaves remaining. I was informed by residents of the place that this was the third time the leaves had been destroyed during the season, and examination showed that on some of the trees the leaves then present were young and tender and had not yet attained the normal size. So far as I could learn in the brief time at my disposal, nothing whatever had been done to check the injury.

The adult beetles were abundant at the time on the trunks of infested trees, on the leaves, and on the ground. Many had but recently acquired wings, as was shown by the softness of their integument and absence of the characteristic markings. They were still feeding, but it was evident that their period of activity was about over and that they would soon scatter and find concealment for the winter months. A few of the grubs also remained about the leaves, while at the bases of some of the trees were masses of the insects in all three stages, grub, pupa and adult, the latter consisting of many bodies of spent and dead individuals, with some just transformed, and still others with markings denoting complete maturity. Only the eggs were at this time lacking to represent all the stages in the life-history of the insect.

Nature of the Injury.

The injury to these English elms is very simple and easily understood, being entirely different from that suffered by our native white elm. The grub of the beetle is provided with jaws and gnaws away and devours the leaves, eating at first only the green portion and thus producing numerous whitish spots, as shown in the illustration. The adult beetle also eats the leaves and does a good deal of the mischief. As already stated, the insect does not attack American elms to such an extent as to be the occasion of anxiety for them. Examples of these, standing near badly infested English elms at Bardstown, were noticed to be entirely free from attack. Experience with the pest in other parts of the country is to the same effect, though in some observed instances our elms have been resorted to by broods of beetles that were starved to it by exhausting the foliage on European elms.

Description.

The Adult. Length about ¼ inch ; greatest width about ⅛ inch ; somewhat flattened from above downward, but the back convex. General color obscure yellowish brown. Head immersed in the thorax, marked with a transverse black spot above the bases of the antennæ, which may or may not be connected with a triangular black spot on the occiput ; a broad black spot behind each eye, sometimes concealed ; antennæ short, about half the length of the body ; pale, edged with black. Thorax short and wide, deeply indented each side of the middle, with a black spot on each side near the outer margin, and a third of smaller size before the middle of the hind margin, this latter spot extending forward toward the front and sometimes terminating in a slightly expanded tip. Legs short, pale, often with a black dot above on each femur, generally with one below on the two hind pairs ; tibiæ with a line of black behind. Triangular plate (scutellum) at base of wing covers with a transverse central black spot. Wing covers with a stripe of black extending from the front margin and gradually expanding to terminate without reaching the hind margin. A narrow line extends backward from the

front edge of each wing cover, inside the large stripe, and terminates rather abruptly about 1-6 the distance to the hind extremity. Body beneath pale at the margins; dark centrally.

The colors vary a good deal in individuals, some being very dark with the markings scarcely discernible while others present the ground color and black stripes and spots in sharp contrast. The beetle resembles in general shape the well known striped cucumber beetle, is in fact a member of the same family.

The Pupa. Length rather less than ¼ inch, owing to the front and hind parts of the body being bent downward; width about ⅛ inch; back arched, under side incurved. White, without evident markings, but under a hand magnifier seen to be marked above with regularly arranged black dots, from each of which arises a short black bristle. Margins of three abdominal segments with flattened, plate-like projections, each with a short black tooth. Head, legs, and wing-pads folded close against the breast.

The Larva or Grub. Length about ⅓ inch; diameter about 1-10 inch; rather blunt at extremities. Skin roughened with small tubercles bearing short hairs, those forming two series on the lower part of each side being larger and more conspicuous. General color brown, young being lighter, older ones nearly black, with a wide band of black along each side, formed of closely placed black spots. Head and legs black.

The Egg. About 1–25 inch in height, being conical and pointed at the free end, the attached end being broadest. Yellow, or dull whitish in color if empty. Attached to the under sides of leaves in elongate clusters of from 15 to 30 eggs.

On the approach of cold weather the beetles leave the elm trees and scatter about in search of hiding places for the winter. These they find in all sorts of crevices about outbuildings, fences, and refuse of various sorts, and here they lie dormant until the following spring, when the warmth of the sun stirs them to activity again. They resort to the trees and begin to feed on the young leaves as soon as the latter

appear, eating round holes in them and often riddling them badly. At the same time they place the clusters of eggs on the under sides of the young leaves, producing in all as many as six hundred, but scattering them about in small clusters, so that the young may not suffer from being over crowded. They may be present about the trees for three weeks or a month. When the young larvæ hatch they feed on the green substance of the leaves, gnawing it away from the under side and leaving translucent patches which look like holes when the foliage is between one and the light. All of the green substance may be thus gnawed away, leaving only the brown skeleton. The length of time passed as a grub is about two weeks, when they creep down the trunk of the tree and change to pupæ under rubbish commonly, but sometimes completely exposed on the ground at the base. They pass about two weeks in this quiescent stage, when the skin is moulted, and the adult beetle emerges. It is at first white, like the pupæ, but gradually the skin becomes firmer and darker in hue, the black spots and stripes finally becoming more or less distinct. These beetles resort to the leaves again to lay eggs for a second brood, and thus the injury is kept going all summer; for with the long time required by the female to place all her eggs there is a wide difference in the times of hatching of individuals of the same brood, consequently the broods overlap and there is no time until October when most of the stages of the insect may not be found about the trees. A third brood probably develops at this latitude.

Its Means of Spreading.

The imported elm leaf-beetle was known in eastern states sixty years ago, but appears to have spread slowly, and has not been known in the interior until during the past three years. Its slowness in reaching this State has not been due to any deficiency in its organs of locomotion. The larva creeps rather slowly, having only short legs, and is evidently not the stage chiefly concerned in disseminating the species. The jointed legs of the adult too are rather short, but it can travel well, though slowly, and by their use can easily find its way from tree to tree, when these are not widely separated. But

its relatively large membranous wings are of most importance to it as means of finding new feeding grounds, and there is no reason why it should not, with their use, fly long distances. I suspect it is somewhat handicapped in this country by the fact that it is pretty closely restricted to the English and Scotch elms, and as these are not very generally grown, wandering beetles stand a good chance of starving before finding appropriate food. It seems altogether probable that they were brought to Nazareth with plants of some sort, possibly as eggs on the leaves of young elms, possibly as beetles hibernating among material used as packing.

Treatment.

Gnawing insects such as this can generally be best dealt with by applying poisonous substances to their food This is easily enough done when the plants to be treated are small, but becomes more difficult with trees because of the trouble involved in reaching the tops of large ones. It requires a good strong force pump, and sufficient strongly made hose to allow the one who handles the spray nozzle to climb up a ladder into the tree. For trees from 60 to 75 feet high, fifty feet of hose, together with the brass extension furnished with same pumps, would probably be sufficient. Trees of eastern cities are now sprayed with such appliances every year, and the cost of treatment has been so far reduced that there is no reason why every city with trees as badly infested as these at Bardstown should not make provision for checking the ravages of the insects. It can be done either by giving the contract of treating all infested trees to some person who will provide apparatus, materials and labor, or by the city itself buying the necessary pumps, hose, etc., and taking charge of the work.

The cost of treating trees varies of course with the size and the number of applications necessary. It is claimed that a contractor can make a profit by spraying trees of all sorts several times for a season at one dollar apiece. The actual cost of treatment has been in some instances reduced to as little as fifteen cents per tree. Few people are willing to part with a fine elm for many times the cost of treating it, yet it is to

be feared that many trees in Nelson County will be destroyed before owners are aroused to the necessity for spraying.

In a recent bulletin the State Entomologist of New York, writing of a Daimler gasoline motor (See figure 13), made under the direction of Dr. E. B. Southwick, of the department of public parks, New York City, says that it is perhaps the best apparatus yet designed for spraying trees:

"It consists of a Daimler gasoline motor operating a Gould force pump—the motor and pump weighing but 300 pounds can be placed in the bottom of a spring wagon along with the 100-gallon tank containing the poisonous mixture. This motor has the advantage of being almost noiseless in operation, and is scarcely noticed by passing horses. It is very inexpensive to operate, as a gallon of gasoline is sufficient for a day, and it requires so little attention that a tyro can run it. The smallest size Gould 3-piston pump is the one used with the motor, although Dr. Southwick now recommends a larger one in order to utilize the power more fully. The motor costs $250 and the pump about $50. They can easily supply four lines of hose, although not more than two can be used to advantage in most places."

One of the most charming features of Bardstown is the number of fine elms that line its streets. The citizens of the place could well afford to spend the above amount rather than have them removed, or continually made unsightly by myriads of gnawing insects.

The poison most commonly employed for spraying is Paris green, and water in proportions varying with the plant to be sprayed, some being much more tender than others. About one pound of the poison in 100 gallons of water may be used on elms, but the addition of a pound of slaked lime is recommended by those who have had experience in the East, as a precaution against burning the leaves, and also as a means of making the poison adhere longer. Arsenate of lead and other compounds not soluble in water are now being employed to some extent in place of Paris green, the advantage in their favor being that they can be used in much greater quantities without burning foliage. Arsenate of lead has been used

in the proportion of twenty pounds in 150 gallons of water. This insecticide can now be bought for about 10 cents per pound. It remains in suspension better than Paris green, and contains no particles to clog the nozzle used in spraying.

Time to Spray.

The proper time to spray is early spring, as soon as the leaves unfold and the beetles begin to lay their eggs. A thorough application made at this time should greatly lessen the mischief for the season by destroying both the adults and any young that might subsequently hatch from their eggs. A second application may be required for the young worms if rains follow the first. Where nothing has been done to check the injury, it is probable several additional sprayings will be required. These should be so timed as to get the greatest possible number of insects, and are calculated to do most good when a new brood is appearing. If properly timed and the rainfall is not very great, three sprayings should be sufficient.

Other Treatment.

In addition to spraying, much good can be done by destroying all the worms and pupæ that accumulate just at the bases of the trees. One often sees these so numerous that they can be gathered up by handfuls. While there it is a simple matter to destroy them by the use of a little kerosene emulsion or even hot water.

Enemies.

Several insects have proved valuable friends to us by their onslaughts upon the elm leaf beetle, and their presence about infested elms has sometimes been misunderstood. One of these most likely to attract attention is the praying mantis figured on one of my plates (Fig. 9). It was observed at Bardstown creeping about the infested elms. Another insect noticed feeding on the immature leaf beetles at Bardstown is known as the spined soldier bug (*Podisus spinosus*). Its young was common about the trees. The body is rather flat and about $\frac{3}{8}$ inch long, of a brown color, marked with black. It impales the young beetle on its slender beak and sucks its blood. The

same insect is known in potato patches from its destruction of the young Colorado potato beetle. No doubt many other insects gather about the trees to prey upon the helpless pupæ and in course of time it is to be hoped will appreciably reduce the numbers of the leaf beetles. At present they are not numerous enough, and if the trees are to be saved they must be sprayed.

THE ELM LEAF-SKELETONIZER.

(*Canarsia ulmiarrosorella.*)

The leaves of the white elm are sometimes badly gnawed by a native insect whose work is not unlikely to be mistaken for that of the beetle just described. It is a member of a different order of insects, one of the small moths of the family Tineidæ, a group containing many species with similar leaf-skeletonizing or mining traits. This one eats long holes in the leaf between the veins, working from the upper side, where it spins a slight web for its protection. The very young simply gnaw away the green substance, but as they grow older eat through the leaf as stated. I have seen scattered trees on lawns and in pastures that were severely damaged for a season or two, in one case a tree in my own yard having been attacked. It seems to be held in check by parasites, or enemies of other sorts, to such an extent that its depredations never become general. But its injuries are sometimes not less serious to the trees attacked than those of the imported beetle.

The active stage is the larva or worm, which is green, with a black dot on each side of the head above the cluster of simple eyes, and with a larger dot on each side of the first and second divisions of the body following the head. The jointed legs are pale, or in large examples slightly brownish, while the ten soft false legs are black at the tips. Scattered pale hairs arise from the body, those on the hindmost division being noticeable because of their length. Length of an alcoholic specimen, one-half inch. Young worms are paler, and the head is larger relatively, but the black dots on head and body divisions are as described, though the tips of the false legs are not black.

Worms kept in breeding cages at the Station pupated in

some instances about the leaves, while other examples concealed themselves in earth. The adults emerge early in spring during the latter part of March and in April.

The moth is dull gray in general, with a wing expanse of about five-eighths of an inch, the front wings marked at about the middle with a zig-zag line of black, edged imperfectly within and without with white; outside this is a black central spot, followed by another obscure zig-zag pale line edged with black; the outer edge of the wing narrowly black, the wide fringe gray. Hind wings pale gray, translucent, the margin with the fringe narrowly dusky, then pale. Body gray, the edges of abdominal segments paler.

Treatment.

The same treatment is to be recommended for this insect as for the imported leaf beetle, namely, spraying the leaves with either Paris green or arsenate of lead in water. The winter is probably spent among leaves and other rubbish on the ground, which suggests the advisability of raking up and burning for a few seasons material of this sort accumulating under the infested trees.

THE ELM BARK-BEETLE.

(*Hylesinus opaculus.*)

In all the diseased elms examined by me this season, whether dead or not, was found the work of a small, short, thick beetle, quite different from the larger elm borer and also from the elm curcalio (*Magdalis armicollis*). In some of the trees adult beetles were just making their way into the bark, starting either on the trunk or at rough places at the bases of twigs. In other trees extensive systems of burrows were present, like that figured, and in small cavities made at the ends of individual burrows were grubs, pupæ and occasional recently transformed adults. These latter emerged from time to time during the fall in confinement at the Station, the first coming out September 14, and others scattering along until Oct. 15.

The burrows made by the female of this insect and her own offspring are so different from those of other beetles

mentioned in this bulletin that they would be pronounced to be the work of a different insect by almost any one who might encounter them. The mother beetle bores straight into the bark, selecting a point of entrance in a groove of the rough outer bark where the opening will not readily be perceived. Once in the inner bark next to the wood she makes a straight or slightly curved burrow as wide as her body and an inch or thereabouts long, placing her eggs along its sides. When they hatch, the young grubs bore out from the mother's burrow at right angles, or nearly so, each little grub cutting a channel of its own and gradually extending it until it is an inch and three-quarters or two inches long. It is gradually enlarged towards the outer end, and at the extremity is made the cavity where the grub changes to a pupa, and finally to a winged beetle.

While this small beetle is common here and seems to be a constant attendant of dying and dead elms, it appears to be attracted to them only when they are in the last stages of disease, and has in no case been observed by me making its way into living bark. Its singular burrows sometimes attract the attention of people disposed to investigate the elm disease, and have on several occasions been pointed out to me as probably the cause of the whole trouble. The insect and its work are described here to note the differences between it and the elm borer (*Saperda tridentata*), which is a much larger insect, of entirely different shape, making burrows of larger size and of different character.

Should more extended observations show that the insect makes trouble at times by invading the living parts of trees the same treatment is recommended as for the elm borer.

The opaque brownish black beetle is about 0.08 inch long, of compact build, cylindrical, the surface of head and prothorax roughened with closely placed and rather coarse punctures, the wing covers punctured in lines, with the intervals roughened. Entire body with short and stiff hairs. Antennæ short, with a large balloon-shaped firstjoint (the scape), followed by seven small joints (the funicle), which together about equal the first,

these in turn followed by a compact oval terminal club composed of five additional joints. Scutellum rather large but below the level of surrounding parts. Bases of wing covers elevated and forming a ridge. Legs short, the tibiæ flattened and dentate.

A related insect (*Scolytus destructor*) was known years ago as very destructive to elms in the parks and public gardens of London. Westwood, one of the fathers of Entomology, wrote of it in 1839 that it was annually destroying numerous elms about London and that the mischief was spreading into the neighboring country owing to the "inattention or ignorance of those whose duty it is, or ought to be, to adopt decided measures for stopping the mischief." This pest is fortunately not present in the United States, and as noted above, our own most closely related elm-infesting insect has not thus far shown the same aggressive disposition.

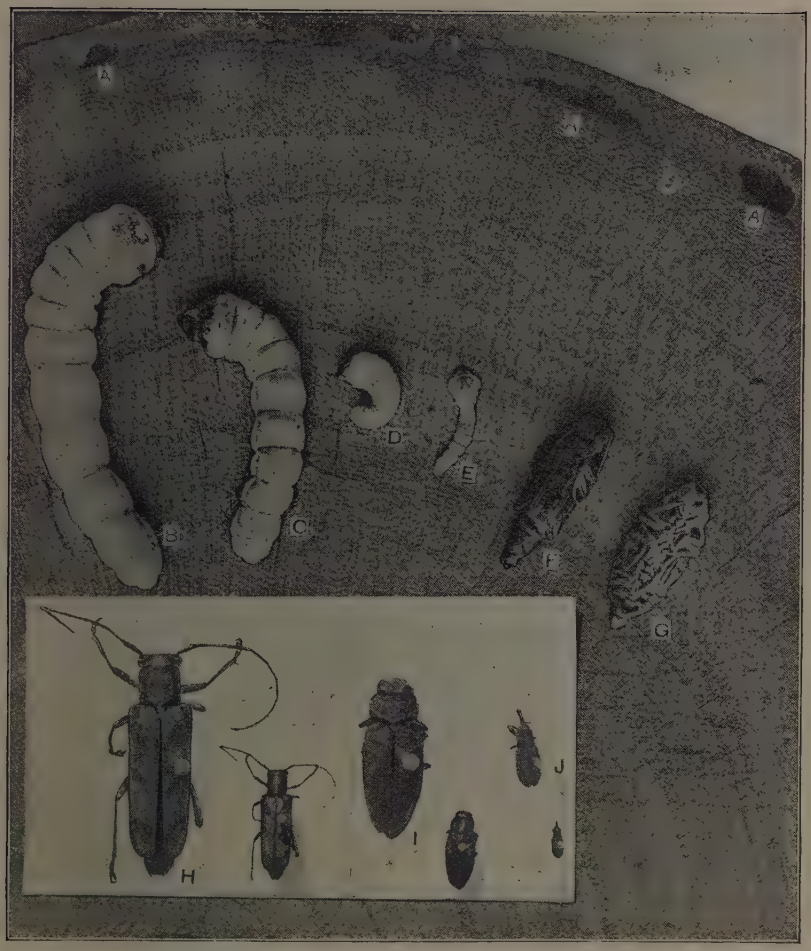


FIG. 7.—Section of the elm represented by Figs 5 and 6, showing the burrows of beetles at A, A, A, in the inner bark. B, C, grubs of elm borers; D, grub of the elm curculio (*Magdalis armicollis*); E, flat-headed grub from white elm; F, pupa of elm borer; G, pupa of flat-headed elm borer; H, adult of elm borer (*Saperda tridentata*); I, adult of flat-headed elm borer; J, elm curculio (*M. armicollis*). Everything enlarged to two diameters, except the small figure at the right of each beetle, which shows the natural size.

FIG. 8.—Showing English elms near the Court-house at Bardstown, stripped of their leaves by the imported elm leaf-beetle (*Galerucella luteola*). A, two adult beetles; B, pupa, seen from beneath; C, larva or grub; the insects all enlarged to two diameters.

FIG. 9.—English elms along same street, looking in the opposite direction. A, preying mantis taken from the trunk of one of these trees; represented of natural size.

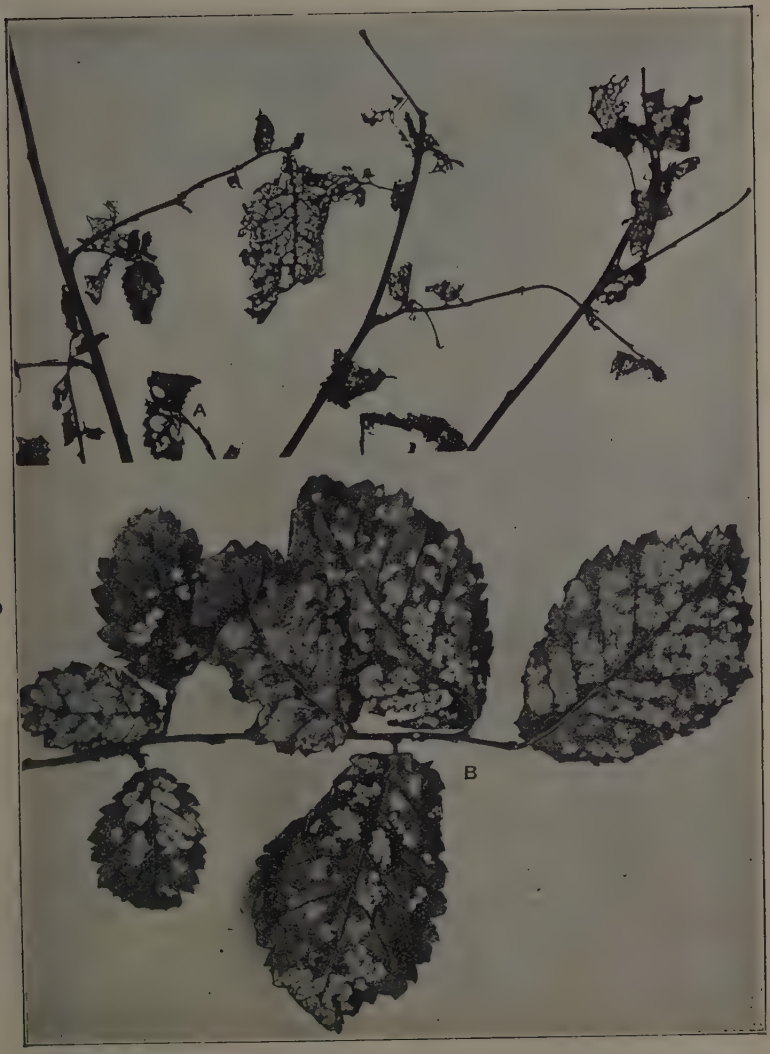


FIG. 10.—Showing leaves of English elms injured by the elm leaf-beetle; A, work of adult beetle (elsewhere the same twigs are injured largely by the larvæ); B, work of larvæ.

FIG. 11.—Showing the burrows made by the elm bark-beetle (*Hylesinus opaculus*) A, the opening by which the adult beetle entered, her burrow extending obliquely across the bark, while those of the grubs hatching from her eggs run, in the main, lengthwise of the bark; B, extremities of larval burrows of another colony, showing the cavities in which the pupæ are formed. Of natural size.

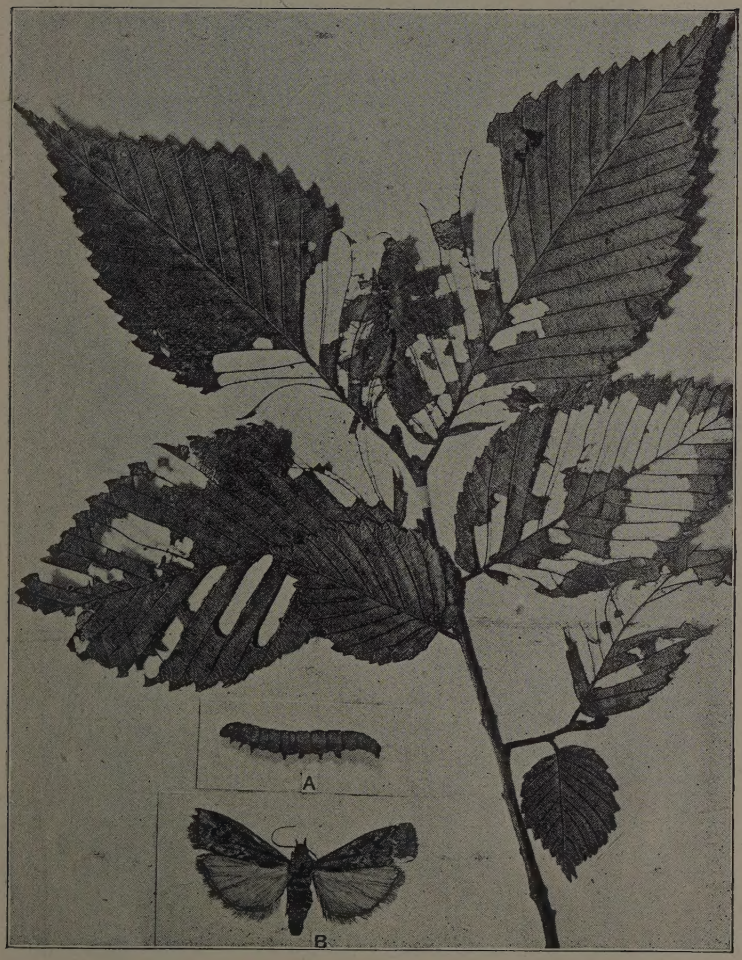
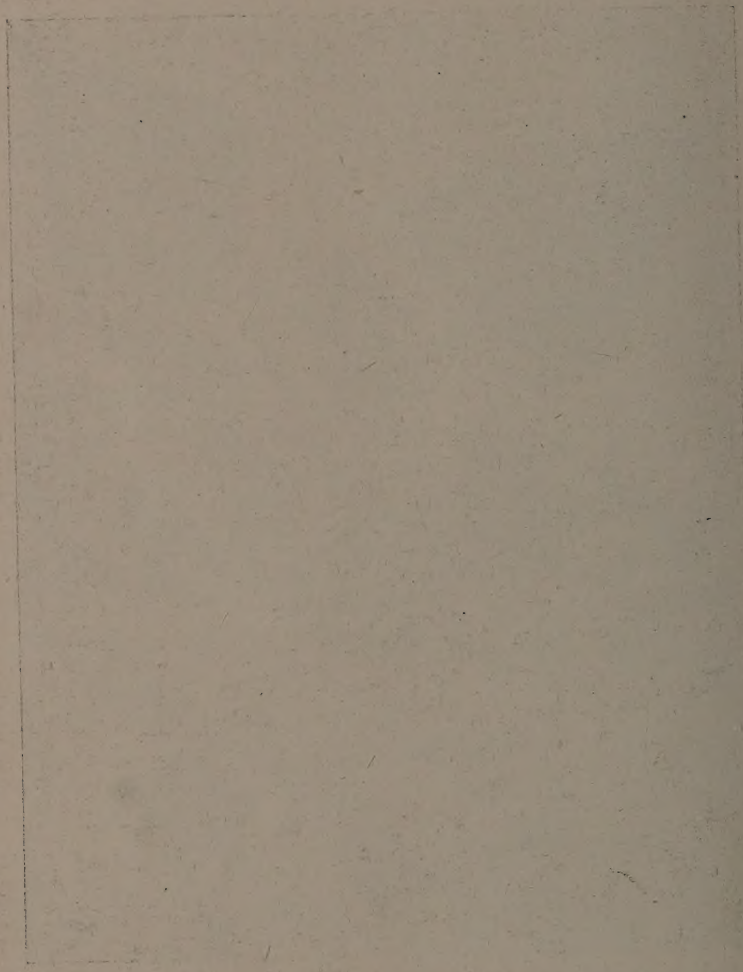


FIG. 12.—Leaves of white elm injured by the elm leaf-skeletonizer (*Canarsia ulmiarrosorella*); of natural size. A, the larva which gnaws the leaves; B, the adult reared from it; both enlarged to two diameters.



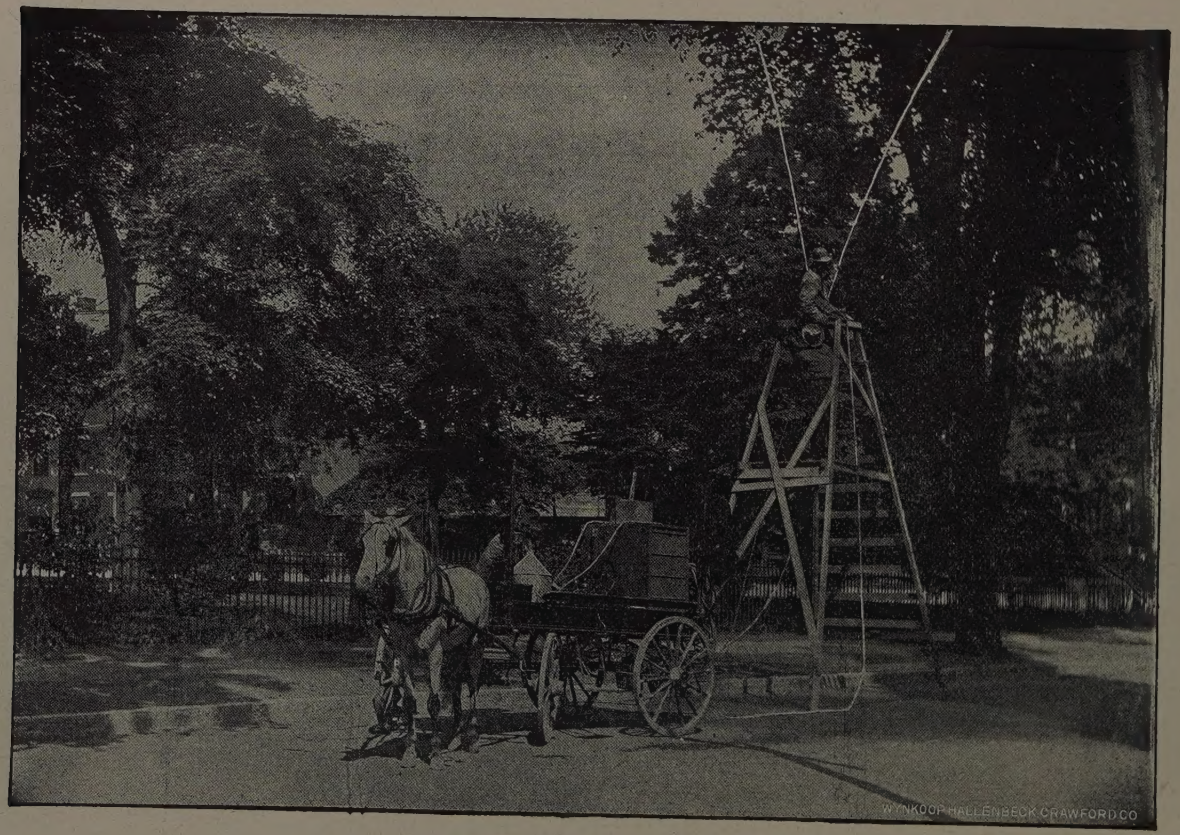


FIG. 13.—A Daimler gasoline motor in operation on the streets of Albany. (From E. P. Felt, Bulletin 20, Vol. 5, New York State Museum.)